FINAL TECH Report

ANNUAL PROGRESS REPORT

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GRANT TITLE: Modelling of Microbiological Remediation of Shipboard Waste Effluents.

REPORTING PERIOD: 30 April 1996-31 August 1996

AWARD PERIOD: 1 April 1994 - 31 August 1996

OBJECTIVE: To develop a mathematical model of the bioreactor used to treat graywater effluents from Navy ships; to assess the performance of the reactor under varying feeds and, in particular, under shock loads.

APPROACH: Experimental observations on a laboratory recycle reactor by A. E. Konopka and coworkers of the Department of Biological Sciences at Purdue University formed the basis of the model formulation. Their chemical characterization studies of graywater effluents guided the formulation of the medium in which biological activity occurs. The organic components served to characterize the substrates while the inorganic components comprised potentially toxic inhibitors to growth processes.

Data on the laboratory-scale reactor are used to obtain the kinetics of growth and deactivation of biomass as a function of the biotic and abiotic phase variables in the reactor. The kinetics are used to simulate and fine-tune kinetic parameters to describe dynamic data obtained on the laboratory recycle reactor over a range of feed concentrations and dilution rates. Special attention is paid to the effects of unusual proportions of components such as bleach or pine oil to assess the response of the bioreactor to "shock loads." Thus experimental observations on the effect of perturbations by the pulse addition of toxicants on the laboratory reactor dynamics are examined with regard to predicting the deactivation and subsequent recovery of the reactor biomass.

ACCOMPLISHMENTS: We have developed a mathematical model of the wastewater treatment which describes well the dynamics of the laboratory recycle reactor obtained from several experimental runs. The waste water comprised three different substrates, starch, linear alky sulfonates (LAS), and protein while the biomass community is viewed as only a single lumped biomass. The contribution of dead biomass to the growth of live cells appeared important to describe the reactor dynamics.

The reactor dynamics following the pulse addition of toxicant could be described by the model using two mechanisms: (i) second order kinetics with respect to toxicant and biomass concentrations for the deactivation of biomass, and (ii) simultaneously introducing inhibition of biomass growth. The model successfully describes the viable biomass trend during the recovery phase of the recycle reactor as estimated from measurements of ATP. These simulations did not show reactor failure under the conditions investigated.

A computer program is now available which can be used to simulate the reactor receiving feed water of continuously varying quality. Pilot plant data could not be obtained from the Naval Facilities at Annapolis to adapt them to the model parameters before the expiry of the

project. **However, the computer software has been supplied to the pilot plant personnel at NAVSWC-Annapolis with the offer to assist them in evaluating the data for parameter estimation even though the period of the project as well as the grant has expired.**

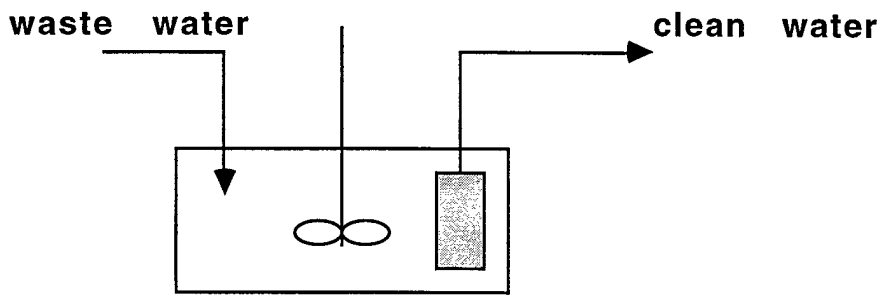
SIGNIFICANCE: The NAVSWC-Annapolis has designed a treatment system that includes a continuous flow bioreactor with biomass recycle. Such a system maintains relatively high biomass levels to allow for high biodegradation rates but a low growth rate to balance the small biomass in the treated effluent entering the separator. The pilot plant data can be used to further validate the mathematical model developed in this project and to examine the effects of various feed conditions including those of shock loads. The model will also serve to develop rational design strategies for bioreactors aboard naval ships.

PUBLICATIONS AND ABSTRACTS:

1. Hogan, M. "Bioremediation of Naval Shipboard Effluents", M.S. Thesis, Purdue University, 1996.

2. Hogan, M., Kumar, S., S. Trinh, T. A. Zakharova, A. E. Konopka and D. Ramkrishna, "A Mathematical Model for Microbiological Remediation of Shipboard Effluents," to be submitted for publication.

Doraiswami Ramkrishna; 1997



Recycle Bioreactor

Objectives

Model of Microbiological Remediation of Shipboard Effluents

- Predict water quality and biomass dynamics in recycle bioreactor
- Predict the effect of accidental addition of toxicants on bioreactor performance

Accomplishments

- Model simulates biomass dynamics well in several recycle reactor runs.
- Model simulates recovery phase of bioreactor from accidental addition of toxicants. Predicts viable mass dynamics from data available currently.
- Have provided the NAVSWC-Annapolis a software for simulating water quality in the pilot plant bioreactor.

Significance

- Provides design procedure of bioreactor aboard ships
- Evaluates potential effects of increased loads of varying types
- Evaluates the effects of accidental pulses of toxicants and estimates recovery time